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Abstract
The 2007 to 2009 Canadian Health Measures Survey (CHMS) collected directly measured physical activity on seven consecutive days for a representative sample of the population aged 6 to 79. Based on the CHMS, half of the active minutes in a day are accumulated between 11:00 a.m. and 5:00 p.m. For children, the most active period is lunch-time (11:00 a.m. to 1:00 p.m.), and for teenagers aged 15 to 19, the after-school period (3:00 p.m. to 5:00 p.m.). Children and youth are more active on weekdays than on weekends. Active children and youth tend to accumulate more minutes of moderate-to-vigorous physical activity after school, whereas active adults do so at lunch time.

Key words
Accelerometer, Actical, activity monitor, body mass index, body weight, exercise

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Canadian children and youth are more active on weekdays than on weekends, while adults have relatively consistent levels of physical activity regardless of the day of the week. At all ages, but particularly among children and youth, most physical activity occurs between 11:00 a.m. and 5:00 p.m., with distinct peaks at lunch time and in the afternoon just after school or work. Time-stamped objective measurement tools allow researchers to determine not only who is doing enough to meet physical activity guidelines, but also when that activity is occurring.

Until recently, population-level trends in physical activity were estimated using self-report surveys and questionnaires, an approach that is subject to recall error and bias.[1-3] By contrast, the 2007 to 2009 Canadian Health Measures Survey (CHMS) used accelerometers to obtain objective measures of physical activity and sedentary behaviour.[4-6] Accelerometers provide minute-by-minute data about steps taken and movement intensity (sedentary to vigorous).

This article identifies the times during the day when people engage in moderate-to-vigorous physical activity (MVPA), based on accelerometer measures over seven consecutive days (see *The data*). Minutes of MVPA are reported for two-hour intervals from 7:00 a.m. to 9:00 p.m., by age group and sex for weekdays and weekends. Patterns of physical activity among the most and least active in the population are also described.

Daily pattern of physical activity

For children and youth, weekdays during lunch hour and after school have been identified as periods when physical activity is high, based on self-reports,[7] pedometers,[8] and accelerometers.[9] Sex differences in the timing of physical activity have also been observed.[10]

Regardless of the person's age, half of all active minutes (at least moderately active) are accumulated between 11:00 a.m. and 5:00 p.m. (Table 1). MVPA accumulation is minimal at night

Table 1
Average daily minutes of moderate-to-vigorous physical activity, by age group, sex and time of day, household population aged 6 to 79, Canada, 2007 to 2009

Age group and sex	Time of day							
	7:00 a.m. to 8:59 a.m.	9:00 a.m. to 10:59 a.m.	11:00 a.m. to 12:59 p.m.	1:00 p.m. to 2:59 p.m.	3:00 p.m. to 4:59 p.m.	5:00 p.m. to 6:59 p.m.	7:00 p.m. to 8:59 p.m.	9:00 p.m. to 6:59 a.m.
6 to 10								
Boys	4.0	9.0*	13.1	11.5	11.4	10.3	8.1[E]	F
Girls	3.1	7.1	11.4	9.4	9.8	8.6	6.8	1.8[E]
11 to 14								
Boys	4.1	5.1	11.1	9.0	10.8	9.0	7.3	3.0
Girls	3.2	4.6	7.6	7.4	9.2	6.4	6.2	2.5[E]
15 to 19								
Men	4.4	5.1*	7.9*	7.5	9.6	6.8	5.7	6.1
Women	3.4	3.2	5.6	6.2	7.8	4.4	4.4	4.2
20 to 39								
Men	2.7	3.3	4.9*	4.6	4.7	4.8	3.7*	3.8
Women	2.3[E]	2.9	3.4	3.5	3.6	3.3	2.5	2.9
40 to 59								
Men	2.7	3.6	4.4	3.8	3.8	3.1	2.4	2.8
Women	1.9[E]	2.9	3.7	3.3	3.0	2.8	2.1	1.8
60 to 79								
Men	1.6	2.5	3.0[E]	2.9[E]	2.5[E]	1.7[E]	1.3[E]	1.5*
Women	1.5[E]	2.2	2.2	2.3	1.5	1.1	1.0	0.5[E]

* significantly different from females in same age group ($p<0.05$)
[E] use with caution
F too unreliable to be published
Source: 2007 to 2009 Canadian Health Measures Survey.

The data

The data are from the 2007 to 2009 Canadian Health Measures Survey (CHMS), which collected physical measurements for the household population aged 6 to 79. The survey excluded residents of Indian Reserves, Crown lands, institutions and certain remote regions, and full-time members of the Canadian Forces. Approximately 96% of Canadians were represented. Data were collected at 15 sites across Canada from March 2007 through February 2009. Ethics approval to conduct the survey was obtained from Health Canada's Research Ethics Board.[11] Details about the CHMS are available elsewhere.[3]

Participants were interviewed at home before visiting a mobile examination centre for a series of physical measurements. Upon completion of that visit, ambulatory respondents were asked to wear an Actical accelerometer (Phillips – Respironics, Oregon, USA) over their right hip on an elasticized belt during their waking hours for seven consecutive days. The Actical (dimensions: 2.8 x 2.7 x 1.0 centimetres; weight: 17 grams) measures and records time-stamped acceleration in all directions, providing an index of physical activity intensity. The digitized values are summed over a user-specified interval of 1 minute, resulting in a count value per minute. Accelerometer signals are also recorded as steps per minute. The Actical has been validated for measuring physical activity in adults[12] and children,[13,14] and step counts in adults and children.[15]

The monitors were initialized to start collecting data at midnight following the mobile examination centre visit. The data being recorded were not accessible by the respondents who were wearing the devices. The monitors were returned to Statistics Canada in a prepaid envelope, where the data were downloaded and the monitor was checked to determine if it was still within the manufacturer's calibration specifications.[4]

A total of 4,440 respondents returned the accelerometer with at least four valid days. A valid day was defined as having 10 or more hours of wear time. Wear time was determined by subtracting nonwear time from 24 hours. Nonwear time was defined as at least 60 consecutive minutes of zero counts, with allowance for 2 minutes of counts between 0 and 100. For each minute, the level of movement intensity—sedentary, light, and moderate-to-vigorous (MVPA)—was based on cut-points corresponding to intensity level. The MVPA threshold was set at 1,500 for children and youth aged 6 to 19,[13] and at 1,535 for adults aged 20 to 79.[16] Minutes were summed by time period, defined as 7:00 to 8:59 a.m., 9:00 to 10:59 a.m., 11:00 a.m. to 12:59 p.m., 1:00 to 2:59 p.m., 3:00 to 4:59 p.m., 5:00 to 6:59 p.m., 7:00 to 8:59 p.m. and 9:00 p.m. to 6:59 a.m. and averaged over the number of valid days. The final response rate for having a minimum of four valid days was 41.8% (69.6% for selected household x 88.1% for selected person x 84.2% for mobile examination centre visit x 80.8% for valid accelerometer results).

Weekend estimates result from average minutes of MVPA on valid Saturday and Sunday, and weekday estimates, from average minutes of MVPA on valid Monday through Friday. Terciles of MVPA represent the weighted 33.3% and 66.6% of daily average of MVPA. Terciles were calculated by age group and sex.

Height was measured to the nearest 0.1 cm using a ProScale M150 digital stadiometer (Accurate Technology Inc., Fletcher, USA), and weight was measured to the nearest 0.1 kg with a Mettler Toledo VLC with Panther Plus terminal scale (Mettler Toledo Canada, Mississauga, Canada).[17] Body mass index (BMI) was calculated as weight (kg) divided by squared height (m) and was classified according to published BMI thresholds: normal (18.5 to 24.9 kg/m^2), overweight (25.0 to 29.9 kg/m^2), and obese (30.0 kg/m^2 or more) for adults.[18,19]

To account for survey design effects of the CHMS, standard errors, coefficients of variation, and 95% confidence intervals were estimated using the *bootstrap* technique.[17,20,21] Statistical significance was set at a p value of 0.05. Bonferroni adjustments were performed when comparing the different time periods. The number of degrees of freedom was specified as 11 to account for the CHMS sample design.[17]

(9:00 p.m. to 7:00 a.m.), ranging from 30 seconds to 6 minutes.

On average, males accumulate more MVPA than do females,[5,6] a difference that generally persists throughout the day. Among children aged 6 to 10 and teens aged 15 to 19, boys are significantly more active than girls during the mid-morning period (9:00 to 11:00 a.m.). At ages 15 to 39, men are significantly more active than women at lunch time (11:00 a.m. to 1:00 p.m.). And at ages 20 to 39, men are significantly more active than women in the early evening (7:00 to 9:00 p.m.).

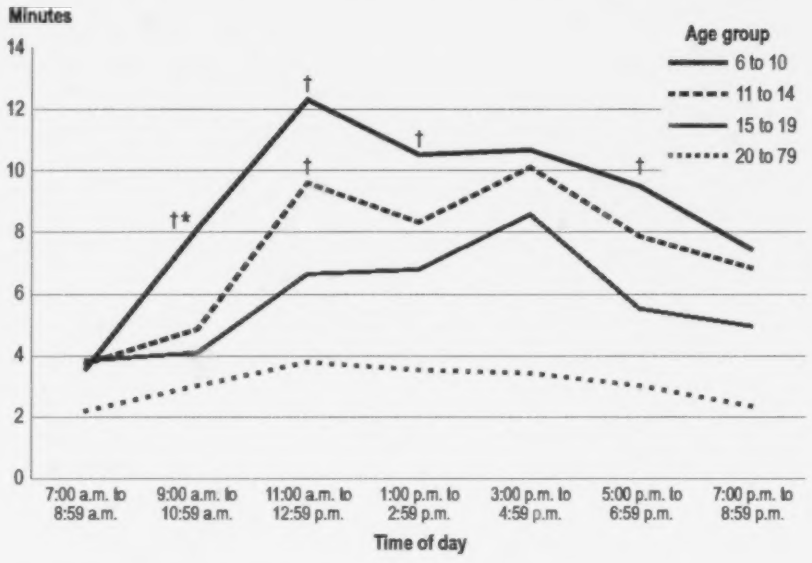
For children aged 6 to 10, the most active period of the day is lunch time, while for adolescents and older teenagers, physical activity peaks from 3:00 to 5:00 p.m., particularly among 15- to 19-year-olds (Figure 1). Compared with the younger age groups, adults accumulate fewer minutes of MVPA in every time period.

Weekends and weekdays

On average, children and youth aged 6 to 19 spend more time in MVPA on weekdays than on weekends (57 versus 47 minutes per day; data not shown). This difference largely reflects more MVPA between 7:00 a.m. and 1:00 p.m. on weekdays (Figure 2). Even based on the percentage of time devoted to MVPA, weekdays are still more active than weekends, meaning that the differences are not due to less time wearing the accelerometer on weekends (data not shown).

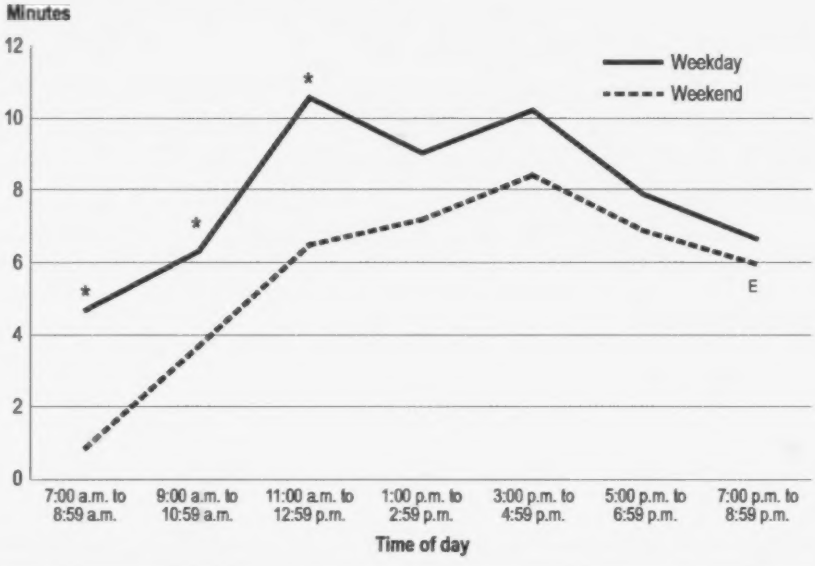
Despite a popular assumption that adults are "weekend warriors" (accumulate the bulk of their MVPA on weekends, but are sedentary throughout the week), studies in the United States indicate that only 1% to 3% of adults fall into this category.[22,23] As well, in the CHMS results, no significant difference emerged in the average time adults spend in MVPA on weekdays versus weekends for the entire day (25 minutes on weekdays, 22 minutes on weekends; data not shown) or for any part of it.

Figure 1
Average daily minutes of moderate-to-vigorous physical activity, by age group and time of day, household population aged 6 to 79, Canada, 2007 to 2009



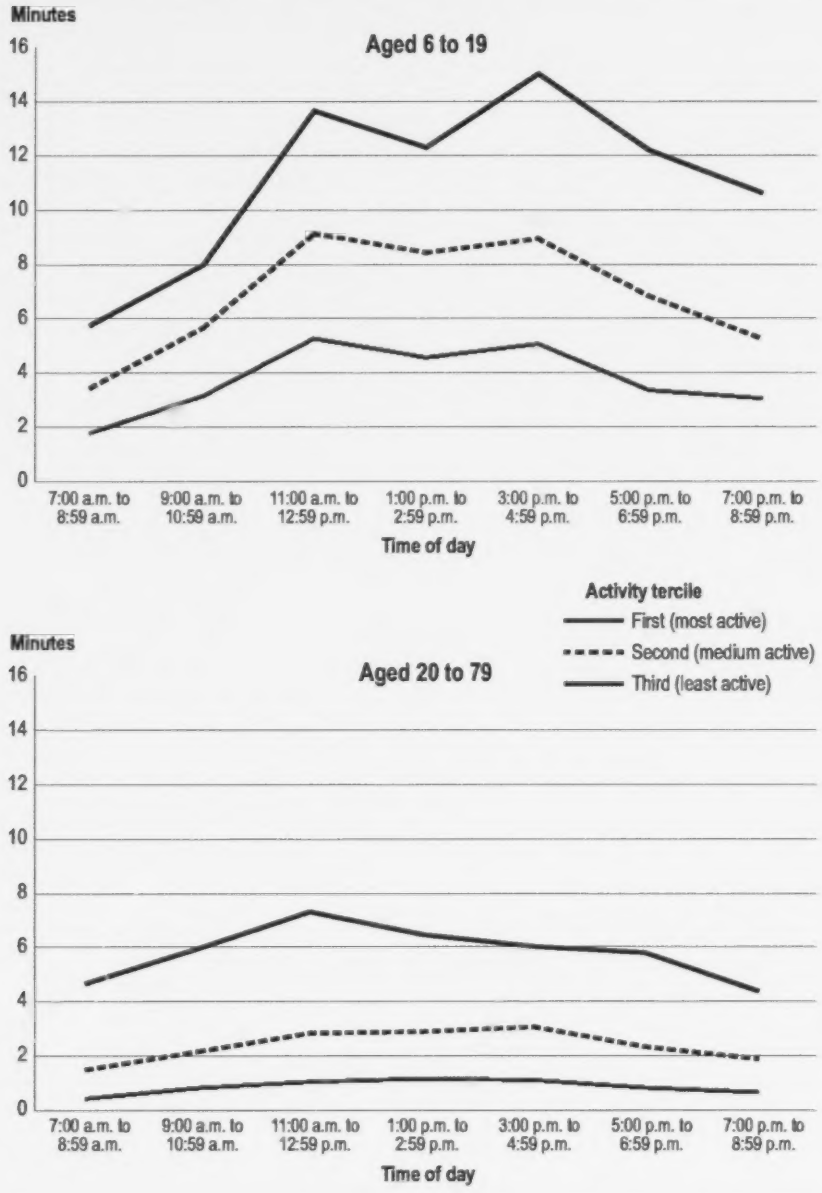
* significantly different from 11- to 14-year olds ($p<0.05$)
† significantly different from 15- to 19-year olds ($p<0.05$)
Source: 2007 to 2009 Canadian Health Measures Survey.

Figure 2
Average daily minutes of moderate-to-vigorous physical activity, by weekday/weekend and time of day, household population aged 6 to 79, Canada, 2007 to 2009



* significantly different from weekends ($p<0.05$)
E use with caution
Source: 2007 to 2009 Canadian Health Measures Survey.

Figure 3
Average daily minutes of moderate-to-vigorous physical activity, by activity tercile and time of day, household population aged 6 to 19 and 20 to 79, Canada, 2007 to 2009



Note: All results for a given activity level differ significantly from the other two activity levels.
Source: 2007 to 2009 Canadian Health Measures Survey.

Most and least active

Fewer than 10% of children and youth meet the current guideline of 60 minutes of MVPA a day.[6] Physical activity levels are also low in adults, with 15% of them accumulating 150 minutes of MVPA in 10-minute bouts per week.[5]

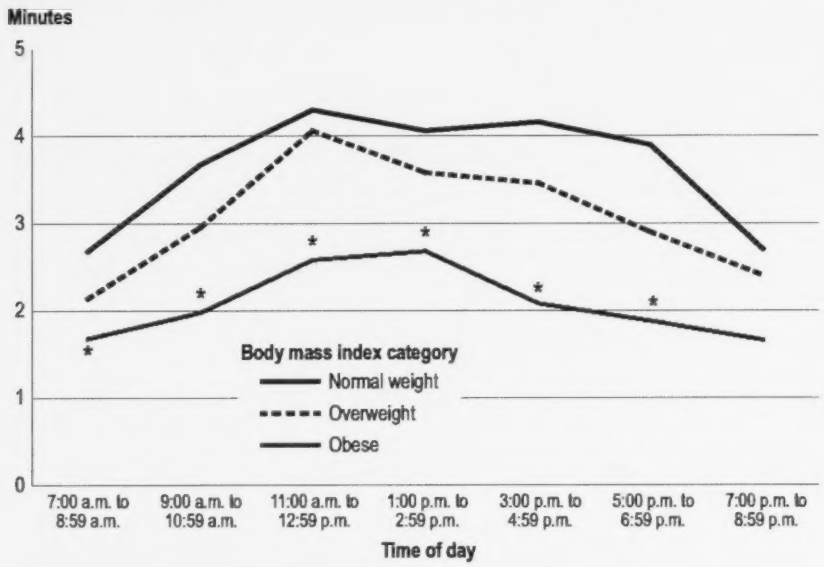
For each age group and by sex, the population was divided into terciles according to MVPA: "least active" (the third with the lowest daily average minutes of MVPA); "most active" (the third with the highest daily average minutes of MVPA); and "medium active" (the third falling in between). For example, among boys aged 6 to 10, the least active accumulate less than 54 minutes of MVPA a day, and the most active, more than 79 minutes. For women aged 60 to 79, the least active accumulate less than 2.5 minutes of MVPA a day, and the most active, more than 12 minutes.

The most active group is not necessarily representative of people meeting physical activity guidelines. For instance, among children and youth aged 6 to 19, 18% of those in the most active group adhere to the guidelines (at least 60 minutes of MVPA a day on at least 6 days out of 7); less than 2% in the medium active and least active groups meet the guidelines. The trend is similar for more modest physical activity targets: close to half (46%) of the most active children and youth accumulate 30 minutes of MVPA a day 6 days a week, compared with 24% of the medium active group, and 5% of the least active group. For adults aged 20 to 79, 42% of the most active group meet the guideline of 150 minutes of MVPA a week; 3% of the medium active group do so, but none of the least active group.

Throughout the day, the most active children and youth accumulate more minutes of MVPA, compared with the other two terciles (Figure 3). The largest difference is just after school from 3:00 to 5:00 p.m.

Similarly, the most active adults accumulate more minutes of MVPA in every period of the day than do those who are less active. For the most active

Figure 4
Average daily minutes of moderate-to-vigorous physical activity, by Body Mass Index category and time of day, household population aged 20 to 79, Canada, 2007 to 2009



* significantly different from normal weight ($p<0.05$)
Source: 2007 to 2009 Canadian Health Measures Survey.

adults, minutes of MVPA peak at lunch time between 11:00 a.m. and 1:00 p.m. (Figure 3). This peak in physical activity was not observed for the average active and least active adults.

Influence of obesity

It has been suggested that the level of obesity can influence patterns of physical activity.[24] According to the CHMS, overweight and obese males aged 6 to 79 accumulate fewer minutes of MVPA a day, on average, than do their normal-weight contemporaries.[5,6] This is also true for females at ages 20 to 79,[5] but not at ages 6 to 19.[6] Obesity does not appear to affect the timing of MVPA accumulation among children and youth. However, among adults, the pattern of physical activity during the day (9:00 a.m. to 7:00 p.m.) differs significantly for those in the normal weight range versus those who are overweight/obese (Figure 4). Specifically, the number of minutes of MVPA remains relatively high from lunch time through to dinner time among normal-weight adults, but declines after 3:00 p.m. among those who are obese.

Conclusion

Within-day timing and patterns of MVPA accumulation are useful in understanding variations in physical activity. Results of the 2007 to 2009 CHMS show that the most active individuals accumulate more minutes of MVPA in every period of the day, but especially at lunch time and in the late afternoon. ■

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